MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2015/2016

ETM4106 – OPTOELECTRONICS AND OPTICAL COMMUNICATIONS

(TE)

11 MARCH 2016
09:00 a.m – 11:00 a.m
(2 Hours)

INSTRUCTION TO STUDENTS

1. This question paper consists of 6 pages with **4** Questions only.

2. Attempt **ALL FOUR** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the Answer Booklet provided.

Question 1

(a) List four advantages and four disadvantages of optical fiber communication. [8 marks]

(b) Consider a step index fiber with 25 μm core radius, a core index $n_1 = 1.48$, and $\Delta = 0.01$.

(i) If $\lambda = 1320$ nm, what is the value of V parameter and how many modes propagate in the fiber? [3 marks]

(ii) Will this fiber be single mode when the operating wavelength is $\lambda = 1320$ nm? [1 marks]

(iii) What percent of optical power flows in the cladding? [1 marks]

(iv) If the core-cladding difference is reduced to $\Delta = 0.003$, how many modes does the fiber support and what fraction of the optical power flows in the cladding? [3 marks]

(c) A 50km optical fiber with loss of 0.2dB/km and has five splices with 0.05 dB losses per splice and two connectors with 0.2 dB per connector; used to transmit a data. The receiver sensitivity is 12μW. Express the minimum transmitter power in both mW and dBm. [9 marks]

Continued...

Question 2

(a) A single step index fiber has a core and cladding refractive indices of 1.43 and 1.41 respectively.

(i) Determine the core diameter for the fiber to permit its operation over the wavelength range 1.48μm to 1.60μm. [6 marks]

(ii) Calculate the new fiber core diameter to enable single mode transmission at a wavelength of 1.30μm. [2 marks]

(b) A multimode, optimum near parabolic profile graded index fiber has a material dispersion parameter of 40 $psnm^{-1}$ km^{-1} when used with a good LED source of root mean square (rms) spectral width 30 nm. The fiber has a numerical aperture of 0.35 and a core axis refractive index of 1.43 using return to zero code.

(i) Determine the total rms pulse broadening per km within the fiber assuming waveguide dispersion to be negligible. [6 marks]

(ii) Estimate the bandwidth-length product for the fiber. [2 marks]

(c) With an aid of energy level diagram explain the operation of Erbium-Doped Fiber Amplifiers (EDFA). [9 marks]

Continued...

Question 3

(a) Consider a graded index multimode fiber that has a core radius a=31μm, a profile parameter α=2.15, a core index n_1=1.3, and an index difference Δ=0.02. The fiber pigtail is spliced to a main transmission fiber, which has a core radius 26μm graded index fiber with a numerical aperture of 0.19 and a profile parameter of 1.8. When the fiber axes are aligned without either a gap, radial or angular misalignment, calculate the insertion loss at the splice. [9 marks]

(b) Assume for GaAS laser diode has a 410μm cavity length, which has an effective absorption coefficient of 15cm^{-1}. For uncoated facets the reflectivities are 0.4 at each end. What is the optical gain at the lasing threshold? [3 marks]

(c) What is the peak emission wavelength from double heterojunction LED, which has power generated internally 30mW at a drive current of 40mA. Consider that, the radiative recombination lifetimes of the minority carriers is twice than the nonradiative of recombination lifetimes of the minority carriers in the active region. [5 marks]

(d) Give comparison between LED and laser diode considering different parameters. [8 marks]

Continued...

Question 4

A dense wavelength division multiplexing (DWDM) optical transmission system is designed to have 50GHz channel spacing.

(a) How many wavelength channels can be utilized in c-band (1530 to 1565nm)?

[7 marks]

(b) Consider that, the number of channels calculated at section (i) used to carry information from Kuala Lumpur to Melaka (150 km) using single mode fiber with a loss coefficient of 0.25dB/km. The link contains different amplifiers, where one booster amplifier was deployed with gain equal 10dB, and two intermediate amplifiers, each have a gain of 15 dB, and one pre-amplifier with gain equal 10dB. An optical filter loss deployed in front the receiver is 2 dB, and the loss encountered by each channel on passing through a multiplexer and De-multiplexer is 0.3dB. Considering the receiver sensitivity for each wavelength channel is -16.6dBm, calculate the required minimum transmission power for each wavelength channel (allowing a power margin of 4 dB).

[10 marks]

(c) If each laser used in section (b) has a spectral line width of 0.7nm, and a 3dB bandwidth of 7GHz, and the dispersion parameter of the fiber used is 1ps/km.nm at the transmission wavelength. Calculate the maximum system rise time and the material dispersion rise time of the fiber if we wish to transmit 5Gb/s NRZ data on each wavelength channel. What is the required bandwidth of the receiver?

[8 marks]

End of Page

Appendix I

Physical constants:

vacuum permittivity

$$\varepsilon_0 = \frac{10^{-9}}{36\pi} = 8.85418\times10^{-12}\ F/m$$

Vacuum permeability

$$\mu_0 = 4\pi\times10^{-7} = 1.25663\times10^{-6}\ H/m$$

Boltzmann constant

$$k_B = 1.38066\times10^{-23}\ J/K$$

vacuum intrinsic (wave) impedance

$$\eta_0 = 120\pi[\Omega]$$

elementary charge

$$q = 1.60218\times10^{-19}\ C$$

$$1eV = 1.60218\times10^{-19}\ J$$

Plank's constant

$$h = 6.62617\times10^{-34}\ J-s$$

Speed of Light

$$c = 2.998\times10^{8}\ m/s$$